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EFFECTS OF CONSERVATION RESERVE PROGRAM FIELD AGE ON AVIAN RELATIVE ABUNDANCE, DIVERSITY, AND PRODUCTIVITY

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ABSTRACT.—Introduced grass dominated Conservation Reserve Program (CRP) fields were monitored in summer 1992 in Gratiot County, Michigan, to determine the relationship between field age and avian relative abundance, diversity, and productivity. Younger CRP fields (1–2 years old), best described as a combination of forbs and bare ground, had the greatest diversity and relative abundance of avian species. Older CRP fields (3–5/6 years old) were a combination of grasses and deep litter cover and had the greatest avian productivity. We recommend that after 3–5 growing seasons CRP fields be manipulated to provide a variety of successional stages to maintain simultaneously high avian relative abundance, diversity, and productivity. *Received 6 Nov. 1995, accepted 1 May 1996.*

Specialization and intensification of agricultural practices have contributed to dramatic declines in wildlife populations over the last 60 years (USDA 1972). These land-use practices have decreased the availability of cover types (i.e., number of grasslands and wetlands) available for many farmland wildlife species (Berner 1988). In the Midwest, agricultural practices that adversely impact wildlife are commonly used because the production of quality wildlife habitat provides reduced economic returns to farmers compared to commodity production (Langer 1979). To alleviate excess commodity production and to combat the effects of past agricultural practices, the federal government initiated land retirement programs beginning in the 1930s. These programs provided varying amounts and qualities of wildlife habitat (Berner 1988). The most recent land retirement program is the Conservation Reserve Program (CRP). The CRP provisions of the 1985 Food Security Act (Farm Bill) provide economic incentives to farmers to remove highly erodible and environmentally sensitive cropland from production for 10 years. Perceived benefits of this program include curtailing soil erosion and excess commodity production and creating wildlife habitat.

The CRP offers a unique opportunity to view the successional dynamics of grasslands and associated changes in wildlife populations for 10 years. Avian communities should provide insight into the quality of habitat provided by the CRP because avian species are excellent indicators of habitat quality and respond quickly to environmental changes (Graber

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and Graber 1976). Determining which age or ages of CRP fields support the greatest relative abundance, diversity, and productivity of avian species provides a framework on which management recommendations can be based. Once created and maintained, these grassland habitats should increase the above-mentioned avian variables in a landscape dominated primarily by less diverse agricultural monocultures. The objective of this study was to determine the relationship of various age classes of CRP fields to avian relative abundance, diversity, and productivity by quantifying vegetation structure and composition of CRP fields and the associated changes in avian variables.

STUDY AREA AND METHODS

Nineteen 6.5–20 ha study sites were selected in Gratiot County, Michigan, in 1992. Each CRP field varied in age from 1–6 years (1–4 [N = 3 in each], 5 [N = 6], and 6 years [N = 1]) and was planted to introduced grasses and legumes (alfalfa [*Medicago sativa*], orchard grass [*Dactlyis glomerata*], timothy grass [*Phleum pratense*], and clover [*Trifolium* spp.]) (Millenbah 1993). None of the fields in this study was mowed, grazed, burned, or disced since contract initiation.

Data collected in 1992 represent a time-specific analysis of different age CRP fields. Rather than use a cohort approach, where a sample of fields would be examined annually for a number of years, representatives from different age classes were observed within a year. Using this approach, two assumptions were made. First, it was assumed that all fields selected for observation received similar treatment. That is, all fields were planted in a similar manner to a similar mix of grasses and legumes, and no field had been disturbed since contract initiation. Second, it was assumed that weather had affected fields similarly. However, if there were differences among fields, for either assumption, it is likely that they were distributed randomly across age classes. Therefore, because both assumption were likely met, the time-specific approach provides an adequate representation of the changes in the measured variables as CRP fields age.

Vegetation structure and composition data were collected along six permanent 100 m long, systematically established transects in each field, with six sampling points per line. Sampling occurred every 20 m along each transect in May (peak avian breeding season). Horizontal cover was assessed 4 m from a Robel pole (Robel et al. 1970). Maximum height of living and standing dead vegetation was recorded at each sampling point. Percentage canopy cover of live and dead vegetation; percentage canopy cover of grasses, forbs, and woody vegetation; percentage litter cover; and percentage bare ground were assessed using a 50 by 50 cm sampling frame (modified from Daubenmire 1959). Frequency of all herbaceous species occurring within the sampling frame and litter depth were recorded at each sampling point.

Bird censuses were conducted in each field to determine relative species abundance and diversity. Counts were made from 1 May–15 August every two weeks. Censuses were made from transects spaced 50 m apart along the long axis of the field. Censuses were conducted from sunrise to three hours after sunrise. Counts were not made if it was raining or if wind speed exceeded 16 kph. Observers walked slowly along transect lines making frequent stops to scan for birds. All birds seen or heard were recorded. Only those birds observed within 25 m of either side of the transect were included in the census to minimize double counting. Relative bird abundance was reported as birds/ha.

Entire fields were searched for nests to quantify nesting success on different age classes of CRP fields. Nine fields representing three age classes (1 [N = 3], 4 [N = 2], and 5 years old [N = 4]) were searched in mid-May and mid-June. Searches were conducted with 3–6 observers walking 1–2 m apart until fields had been completely traversed. Nests were revisited every 2–3 days until young had fledged or the nest was determined to be abandoned or destroyed. Incidentally discovered nest were also monitored.

Comparisons of vegetation variables and avian relative abundance and diversities among age classes within sampling periods and nesting success among age classes were made using Kruskal-Wallis (KW) one-way analysis-of-variance (Siegel 1956). A KW multiple comparison test (Miller 1980) was used to determine which field age classes were significantly different if there was a significant ($\alpha = 0.10$) KW result. Because there was only one 6-year-old field, this field was combined with 5-year-old fields for all statistical tests (hereafter referred to as 5/6) on avian relative abundance and diversity and vegetation variables.

Avian diversities were calculated using the Shannon-Weaver diversity index. Nest success (nests surviving from initiation of egg laying to fledging) was calculated using the Mayfield (1961) method.

Friedman's two-way analysis-of-variance (Siegel 1956) was used to test for differences among age classes for avian relative abundance and diversities over the census period (May–August). Blocking was done on the census period. A Friedman's multiple comparison test (Miller 1980) was used to determine which age classes were significantly different over the census period if there was a significant ($\alpha = 0.10$) Friedman's result.

Friedman's two-way analysis of variance also was used to test for differences in relative frequencies of dominant plant species among fields within an age class. The five plant species with the greatest relative frequencies on each field were included in the analysis. Failure to reject the null hypothesis would suggest that an age class of CRP field could be described by the dominant plant species present.

Principal components analysis (PCA) was used to examine the relationship between field age, vegetation characteristics, and avian relative abundance and diversities. Because measured vegetation variables may be related, PCA was used to reduce the number of variables to a few independent variables. The new variables, or principal components, were linear combinations of the original vegetation variables. The linear combinations maximized the variance in the data and could be used to identify the original variables most significant in describing a particular age of CRP field. Analysis was done using a correlation matrix.

RESULTS

Eighty-two plant species were identified on 19 CRP fields. Individual fields within each age class differed (Friedman, $P < 0.10$) in the relative frequencies of plant species identified. Therefore, a particular age of CRP field could not be described by the dominant plant species present. These findings preclude any meaningful test of changes in dominant plant species composition as fields age. Similarly, we observed no consistent successional replacement of dominant plant species as fields aged (Millenbah, unpubl. data).

Vegetation characteristics that differed significantly (KW, $P < 0.10$) among age classes included horizontal cover, percent total canopy, percent live canopy, percent dead canopy, percent grass canopy, percent forb canopy, percent litter cover, percent bare ground, and litter depth (Table 1). However, none of the significant differences was consistently related to

TABLE 1

MEAN (SE) VEGETATION CHARACTERISTICS ON DIFFERENT AGE CLASSES OF CONSERVATION RESERVE PROGRAM (CRP) FIELDS

Characteristic	Age class[N][a]				
	1[3]	2[3]	3[3]	4[3]	5/6[7]
Horizontal cover (dm)[b]	2.5^{A} (0.4)	3.6^{AB} (0.6)	3.3^{AB} (0.3)	4.1^{B} (<0.0)	3.1^{AB} (0.3)
Height of live vegetation (dm)	2.9 (0.5)	4.5 (0.9)	4.4 (0.5)	5.2 (0.2)	3.7 (0.4)
Height of dead vegetation (dm)	7.4 (0.7)	9.2 (0.4)	9.2 (1.1)	9.4 (1.4)	9.3 (1.1)
% Total canopy[b]	55.1^{B} (4.6)	84.3^{AC} (1.5)	57.2^{B} (5.3)	82.8^{C} (6.9)	61.2^{ABC} (2.2)
% Live canopy[b]	51.4^{A} (3.3)	74.6^{B} (1.6)	53.1^{AC} (5.6)	73.3^{BC} (5.6)	56.1^{AC} (2.3)
% Dead canopy[b]	3.9^{A} (0.9)	8.8^{B} (0.5)	4.6^{AB} (1.1)	9.4^{B} (1.6)	5.7^{AB} (0.7)
% Grass canopy[b]	26.9^{A} (4.2)	26.9^{A} (11.1)	45.4^{AB} (7.8)	53.8^{B} (2.6)	41.6^{AB} (3.0)
% Forb canopy[b]	29.1^{AB} (0.4)	54.8^{A} (10.6)	12.5^{B} (2.2)	28.4^{AB} (8.2)	20.7^{AB} (3.6)
% Woody canopy	0.0 (0.0)	0.8 (0.7)	<0.1 (<0.0)	0.0 (0.0)	0.2 (0.1)
% Litter cover[b]	25.6^{A} (12.2)	40.2^{A} (3.4)	57.5^{B} (3.8)	45.8^{AB} (1.4)	54.2^{AB} (1.9)
% Bare ground[b]	33.2^{A} (11.8)	7.1^{AB} (2.7)	2.5^{B} (1.6)	2.2^{B} (1.2)	2.5^{B} (0.7)
Litter depth (cm)[b]	2.3^{A} (0.9)	3.1^{AB} (1.8)	11.3^{B} (3.2)	6.7^{AB} (1.1)	5.6^{AB} (1.1)

[a] Five- and 6-year-old fields combined.

[b] Significantly different among age classes (Kruskal-Wallis, $P < 0.10$). Within the same row, means having the same letter are not significantly different (multiple comparison test, $\alpha = 0.10$. Miller 1980).

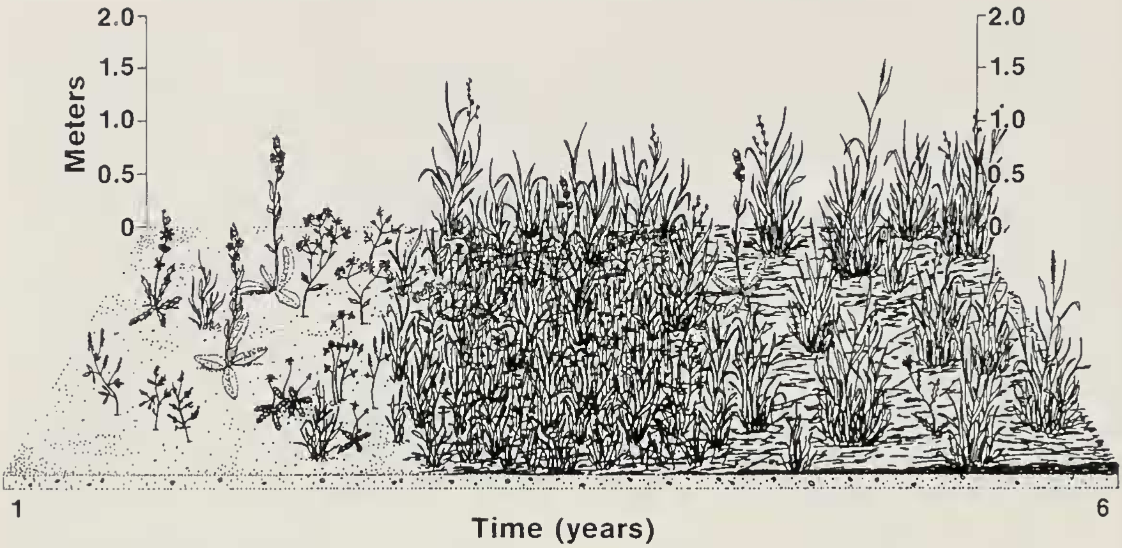

FIG. 1. Diagrammatic representation of changes in vegetation structure and composition on a Conservation Reserve Program field over the first six growing seasons.

field age. General patterns for horizontal cover, height of live and dead vegetation, percent total canopy, percent live canopy, percent dead canopy, and percent forb canopy suggest an increase (but not necessarily significantly) from 1- to 4-year-old fields, with the exception of a decrease in these variables during the third growing season (Fig. 1). These vegetation characteristics all decreased from the fourth to 5/6 growing seasons. Percent grass canopy increased through the fourth growing season, decreasing in the 5/6 growing season. Percent litter cover increased with field age, stabilizing after the third growing season. Litter depth was greatest during the third growing season, subsequently decreasing through the 5/6 growing season, whereas percent bare ground decreased from 1- to 5/6-year-old fields.

The first three principal components accounted for 81.5% of the variance in the vegetation variables (Fig. 2). Principal component one (PC 1), explaining 35.2% of the variance, represents a successional change in vegetation attributes from greater percent total and live canopy to greater percent litter cover and litter depth. Percent total canopy included percent live canopy and percent dead canopy but not percent litter cover. The second principal component (PC 2), explained 32.5% of the variance and represents a successional change from greater percent grass cover to greater percent forb cover. Principal component three (PC 3), explaining 13.7% of the variance, represents a successional change from greater percent bare ground to greater percent litter cover.

Thirty-two avian species were encountered on the CRP fields. The most common species encountered were Red-winged Blackbirds (*Agelaius*

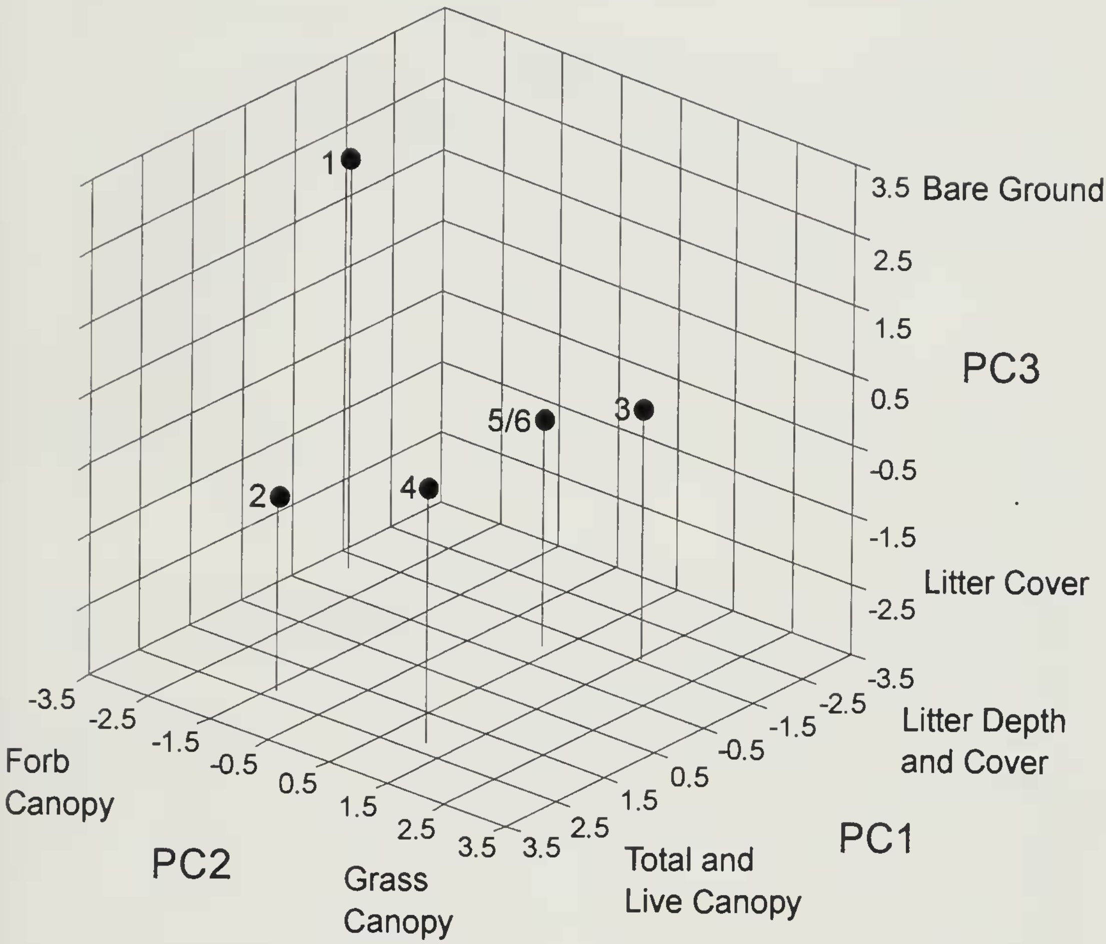

FIG. 2. Mean principal component (PC) values for the first three principal components for different age CRP fields. Age classes correspond to the appropriate number located at each point.

phoeniceus), Song Sparrows (*Melospiza melodia*), Bobolinks (*Dolichonyx oryzivorus*), and Sedge Wrens (*Cistothorus platensis*).

No differences (KW, $P > 0.10$) were detected in bird diversities within a census count among age classes. However, mean avian diversities were different (Friedman, $P = 0.04$) for the entire census period among age classes (Table 2), with 1-year-old fields having significantly greater diversities than 5/6-year-old fields.

Only the periods of 16–31 May and 1–15 August showed differences (KW, $P = 0.06$) in avian relative abundance among age classes, with 5/6-year-old fields having significantly lower relative abundance than 4-year-old fields for the period 1–15 August. However, a KW multiple comparison test did not detect differences among age classes for the period 16–31 May. Mean avian relative abundances were different for the entire census period among age classes (Friedman, $P = 0.01$; Table 2). Five/

TABLE 2

MEAN AVIAN RELATIVE ABUNDANCE (BIRDS/HA) AND DIVERSITY (SHANNON-WEAVER) ON DIFFERENT AGE CONSERVATION RESERVE PROGRAM (CRP) FIELDS[a]

Age class[b]	N	Relative abundance (SE)	Diversity (SE)
1	3	4.24 (1.01)^{AB}	1.37 (0.07^{A}
2	3	3.72 (0.63)^{AB}	1.36 (0.10)^{AB}
3	3	3.30 (0.50)^{AB}	1.28 (0.08)^{AB}
4	3	4.67 (0.57)^{A}	1.18 (0.04)^{AB}
5/6	7	2.12 (0.19)^{B}	1.15 (0.06)^{B}

[a] Within columns, means with the same letter are not significantly different (Friedman's multiple comparison, α = 0.10, Miller 1980).
[b] Five- and 6-year-old fields combined.

six-year-old fields had significantly lower relative abundance than 4-year-old fields. Avian relative abundances decreased from 1- to 5/6-year-old fields with an increase on 4-year-old fields.

We found 166 active nests in three age classes of CRP fields. Nesting species monitored included Red-winged Blackbird, Vesper Sparrow (*Pooecetes gramineus*), Sedge Wren, Northern Harrier (*Circus cyaneus*), Mallard (*Anas platyrhynchos*), Ring-necked Pheasant (*Phasianus colchicus*), and unidentified sparrow species. Red-winged Blackbirds were the primary nesting species observed with 83.1% of the monitored nests.

No difference (KW, P = 0.29) was found in percent successful nests among 1-, 4-, and 5-year-old fields. However, nests on older fields (4- and 5-year-old) had greater probabilities ($\hat{S}_{Mayfield}$ = 0.283 and 0.293, respectively) of surviving from initial egg laying to fledging than 1-year-old fields ($\hat{S}_{Mayfield}$ = 0.138). Mean number of active nests (nests have at least one egg or young within the monitoring period) on 1-, 4-, and 5-year-old fields was 10, 22, and 23, respectively.

DISCUSSION

Although we could not distinguish age classes of CRP fields by the presence of particular dominant plant species (i.e., alfalfa, orchard grass), they could be described by gross structural characteristics (i.e., grass canopy, forb canopy). Fields in this study may be described as in a gradient from greater forb cover and bare ground in the youngest fields to greater grass and litter cover in the oldest (Fig. 1). Forb canopy cover was greater on younger fields due to initial seed mixtures and the natural invasion of other plant species, with many annual forbs responding to soil disturbance. Because of the recent disturbance of planting, bare ground was more dominant than litter cover on younger fields.

Two-year-old CRP fields, however, were best described by moderate forb canopy and litter cover, with a greater total/live canopy than bare ground (Fig. 1). Although the initial seed mixtures of younger CRP fields contained both alfalfa and orchard grass, orchard grass takes several years to establish, whereas alfalfa is noted for its quick establishment (J. Swanson, Gratiot County SCS, pers. commun.). Alfalfa, however, has a relatively short life cycle and begins to die out after two growing seasons. Total/live canopy would be greater on younger fields than litter cover/depth because a substantial litter layer has not yet developed. However, a litter layer was evident, and was proportionally greater than the amount of bare ground present.

Three-, 4-, and 5/6-year-old fields can be described by grass canopy and litter cover, with a decreasing total/live canopy (Fig. 1). As alfalfa begins to die back after the second growing season, grasses begin to dominate sites. The decline in forb cover after the first two growing season may be explained by the loss of alfalfa and other forbs and the encroachment of grasses. Basu et al. (1978) stated that vegetation on a legume dominated field undergoes successional changes, eventually becoming grass-dominated and sparser. As grasses began to dominate and out compete existing forb species, forb cover decreased. Also, as CRP fields age, a litter layer develops decreasing the amount of bare ground and serves as a mechanical barrier to grass development (Rice and Parenti 1978). This barrier decreases productivity of plants present, growth is isolated to surviving clumps, and total/live canopy cover becomes less dense.

It has long been accepted that vegetation structural complexity is associated with avian community structure (MacArthur and MacArthur 1961, Cody 1968). Typically, both avian species diversity and density increase with increasing habitat complexity (May 1982). This may only be expressed on established habitat types (i.e., forests, old fields) and may not be valid for newly established habitats (such as 1-year-old CRP fields).

Habitat complexity is likely not the primary or only factor affecting influx of birds onto 1-year-old CRP fields. Younger fields may meet a variety of habitat needs including feeding and nesting habitat not available on alternative vegetation types present in the landscape, such as agricultural fields. Although nesting did occur on younger CRP fields, productivity was less than that observed on older fields. Younger CRP fields may provide some suitable habitat for nesting, but it is likely that amount and quality of nesting habitat is limited. Roseberry and Klimstra (1984) reported that areas dominated by annual weeds (forb canopy) may provide inferior nesting cover because of the lack of dead grass stems for nest construction.

Older CRP fields did not have the same high avian relative abundances as younger fields. Burger et al. (1990) suggested that CRP fields in Missouri do not provide quality nesting cover for Northern Bobwhites (*Colinus virginianus*) until the third year after establishment. Therefore, it may be possible that a greater quality and availability of nesting habitat was provided on older CRP fields in Michigan, thus supporting greater nesting compared to younger CRP fields.

Cody (1985) stated that avian species composition, or diversity, varies with vegetation structure following a disturbance, thereby creating a diverse array of avian species. Species diversity observed on CRP fields supports this. One-year-old CRP fields, newly disturbed by planting, supported the greatest diversity of avian species. As fields aged and became less disturbed diversities declined.

While many factors may be responsible for increasing avian productivity as fields age, this increase may be an artifact of the most dominant nesting species encountered, Red-winged Blackbirds which nest in a variety of locations with highly variable structural attributes (Granlund 1991). The conspicuous locations of Red-winged Blackbird nests allowed for easier detection. It is likely that nests of other species were missed due to the density of the vegetation. Results may only represent patterns in Red-Winged Blackbird nesting and not productivity of the entire CRP avian community.

Several studies have suggested that grasslands established with seed mixtures similar to planted CRP fields generally did not maintain structural qualities for more than seven years (Higgins et al. 1987). Disturbances on 3- to 5-year intervals enhance avian production by more than 100% (Kirsch 1974, Kirsch et al. 1978). There is general recognition (e.g., Schenck and Williamson 1991) that controlled, periodic treatments to revitalize cover by fire, grazing, or mowing may be necessary for the long-term maintenance of wildlife habitat in grassland ecosystems. Our results indicate perturbations may be necessary to maintain the greatest avian relative abundances, diversities, and productivity on CRP fields after 3–5 growing seasons. Further studies need to be completed to assess fully changes in vegetation attributes and avian diversity, relative abundance, and productivity on fields >6 years old.

Many types of disturbances such as mowing, burning, or discing may create the desired changes in the vegetation. Regardless of the form of perturbation, it should be accomplished in as short a period of time as possible and scheduled to minimize the disruptive effects to nesting wildlife. Although information is available on effects of disturbance practices on grassland birds (e.g., Kirsch et al. 1978), CRP fields are a unique vegetation type in Michigan's agricultural landscape, and little is known about effects of disturbances on avian species using CRP fields. Additional information is needed on maintenance and rejuvenation methods for planted CRP grasslands and responses of avian species to these management practices.

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